Development of a Vertically Profiling, High-Resolution, Digital Still Camera System

Mark C. Benfield,
Louisiana State University
Department of Oceanography & Coastal Sciences/Coastal Fisheries Institute
218 Wetland Resources, Baton Rouge, LA 70803
phone (225) 388-6372 fax (225) 388-6513 email mbenfie@lsu.edu
Richard F. Shaw
Louisiana State University
Department of Oceanography & Coastal Sciences/Coastal Fisheries Institute
218 Wetland Resources, Baton Rouge, LA 70803
phone (225) 388-6734 fax (225) 388-6513 email rshaw@unix1.sncc.lsu.edu
Christopher J. Schwehm
Louisiana State University
Remote Sensing and Image Processing Laboratory
3221 CEBA, Baton Rouge, LA 70803
phone (225) 388-5262 fax (225) 388-5263 email chris@rsip.lsu.edu

Grant Number: N00014-98-1-0563
http://zooplankton.lsu.edu

LONG-TERM GOAL

Our scientific goal is to develop an improved capability for mapping the fine-scale horizontal and vertical distributions of mesozooplankton and other comparably sized particles in the oceans. Mapping of organisms in relation to environmental factors will help to understand the processes that lead to fine-scale patchiness. In-order to collect such biological and physical data, we require a system capable of quantifying zooplankton distributions and abundances on appropriate scales. A central component of this project is to develop a profiling instrument capable of collecting high-resolution images of zooplankton and other particles in the water column and concurrent environmental data on comparable spatial and temporal scales.

OBJECTIVES

1) To interface a high-resolution digital still camera, structured light source and environmental sensors with a surface control and acquisition computer;

2) To develop a graphical software interface to control the instrument; and

3) To evaluate the size distribution and abundance data generated by the profiling instrument in relation to a conventional multi-net (MOCNESS) system.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1999**	2. REPORT TYPE	3. DATES COVERED **00-00-1999 to 00-00-1999**

4. TITLE AND SUBTITLE **Development of a Vertically Profiling, High-Resolution, Digital Still Camera System**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Louisiana State University,Department of Oceanography & Coastal Sciences/Coastal Fisheries Institute,218 Wetland Resources,Baton Rouge,LA,70803**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

APPROACH

Development of the Profiling Instrument

Our zooplankton visualization and imaging system (ZOOVIS) consists of a 2048 x 2048 pixel digital still camera and a structured light strobe coupled to a CTD equipped with conductivity, temperature, pressure, optical transmittance, and fluorescence sensors. This underwater component includes power distribution hardware and fiber-optic multiplexors. A fiber-optic interface on the camera provides the necessary bandwidth to transmit 12bit digital images to the surface at 4 Hz. The underwater unit is connected to the surface via an electro-optical oceanographic cable. Data from the camera and sensors and command and control flow bi-directionally via single-mode optical fibers while power is transmitted to the underwater unit via copper conductors. A surface winch equipped with a level-wind unit and an electro-optical slip-ring assembly controls payout and haulback of the underwater unit. Command and control are from a Pentium II PC running the Windows NT OS.

Evaluation of System Performance

We plan to conduct tank trials of the system at the Louisiana Universities Marine Consortium (LUMCON) facility in Cocodrie, La during spring 2000. We have already arranged to conduct field trials at an offshore petroleum platform, which we will have access to between May and September 2000. MOCNESS comparisons will be conducted using a ship of opportunity during 2000.

WORK COMPLETED

Funding for this project was available in July, 1998 and the project is in its 15th month of operation. Work during the first year of the project focused on developing specifications for the ZOOVIS components and securing the system components.

Digital Camera

Our original design employed a passive backplane PC underwater to handle the command and control of the camera and image acquisition. From there, we planned to send images to the surface over a fast fiber-optic (FO) network to a surface computer. That was necessary because at the time the proposal was written, there were apparently no digital cameras on the market with a fiber-optic interface. Existing cameras all had short RS422 cables and so we planned to run data via RS422 to the underwater PC and transmit it up to the surface PC via a LAN. Our initial plan had been to develop our own fiber-optic interface for a digital camera; however, this would have required an unnecessarily complex underwater unit. We located a digital camera manufactured by PixelVision Inc. that had an integral PCI-bus fiber-optic interface. That camera (BioXite) was built around the same Thompson CCD chip used in the SMD4M4 camera that we originally proposed to use. We ordered a BioXite camera in the fall of 1998 with anticipated spring 1999 delivery. Unfortunately, delivery was repeatedly delayed due to manufacturing problems ranging from metallurgical issues associated with degassing to hardware problems within the fiber-optic interface. A BioXite camera was finally delivered just prior to the production of this report and although the CCD does not meet specifications because of a small number of defective pixels, the camera functions in all other respects. We are using that camera to assemble a working ZOOVIS prototype and will return it to the manufacturer for CCD replacement in December 1999. We believe that PixelVision has now resolved all the hardware and manufacturing issues with the BioXite camera. A new fast zoom lens (Tamron 28-105 mm F2.8) is currently mounted on the camera.

Structured Light Strobe

The digital camera’s high resolution will allow us to image a substantially larger volume of water than is currently viewed by systems utilizing NTSC video. In order to eliminate the need to develop software to classify and reject out-of-focus targets, we opted to use a structured light source. By transmitting a beam of collimated light through the center of camera’s depth of field, only in-focus objects will be illuminated. We have purchased a custom-built strobe system from Seascan Inc. capable of producing a collimated, 20 µsec light pulse with a width of 7 cm and a thickness of 2 cm. This will permit us to photograph a volume of up to 98 ml (7 cm x 7 cm x 2 cm deep) volume of water in each image while maintaining a resolution of 292 pixels/cm.

CTD

Our CTD is a SeaBird Electronics Model SBE19 equipped with a Wetlabs fluorometer and SeaStar transmissometer. We have interfaced an RS232-fiber converter with the CTD so that data can be transmitted via one of the cable’s three fibers. A TrackPoint-compatible underwater acoustic beacon has been delivered and this will be placed on the underwater frame to assist with recovery in the event that the system requires recovery.

Communications and Power Supply

The underwater unit consists of four systems: camera and telemetry, power distribution, strobe and the CTD. The command and control and data flow among these components are illustrated in Figure 1.

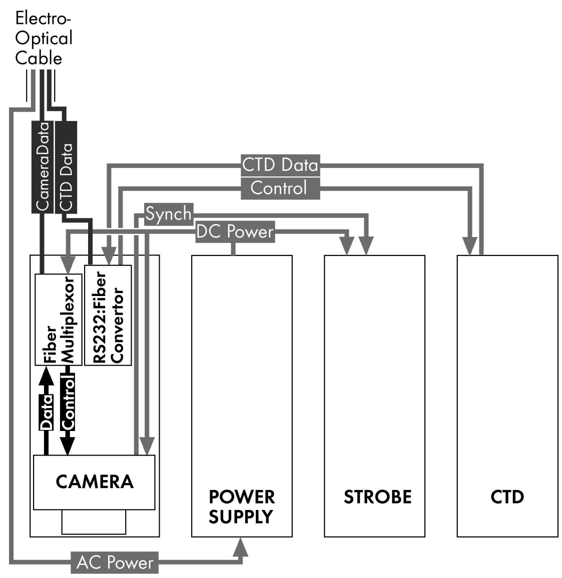

Figure 1. ZOOVIS underwater unit electronic schematic

Electro-Optical Cable, Winch and Slip-Ring Assembly

ZOOVIS is connected to the surface via a 300 m length of custom-built electro-optical cable consisting of three single-mode fibers and three shielded copper conductors surrounded by two contrahelically-wrapped kevlar strength members. The cable is wrapped in a polyurethane jacket. After discussions with Dr. Walter Paul (Woods Hole Oceanographic Institution) we have developed a suitable mechanical termination system for the cable. We have acquired a Sea-Mac Model 210 electro-hydraulic winch capable of paying out and hauling ZOOVIS at up to 1 m/sec. Electro-optical slip rings (Focal Technologies) have been installed on the winch.

RESULTS

At this point we have acquired all components of the system and are proceeding with assembly and testing of a bench-top system. Our current design calls for the system to be mounted on a stainless-steel frame with the camera aimed at 90° to the light sheet. For quantification of smaller particles, the camera will be aimed obliquely into the light sheet. The current design is illustrated in Figure 2. Once we are satisfied with the networking of all system components, we will package the underwater components in pressure housings and proceed with underwater testing.

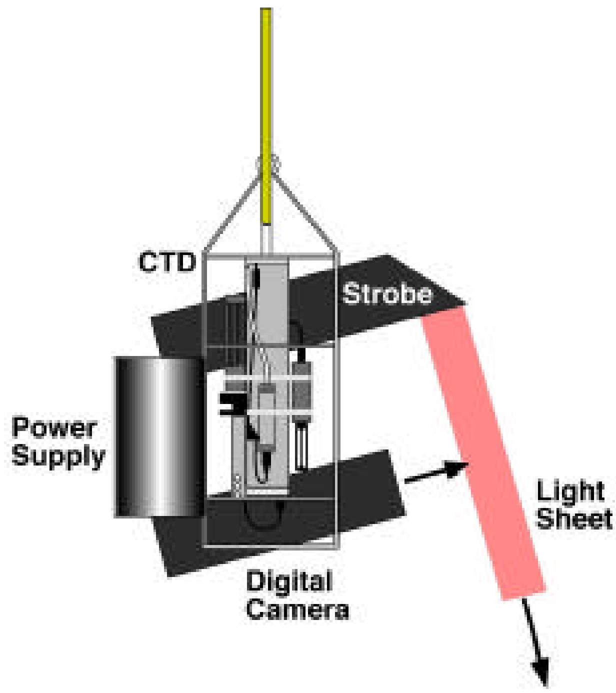

Figure 2. Schematic diagram of the underwater component of ZOOVIS. The system utilizes a PixelVision BioXight 2048 x 2048 pixel, 12 bit camera system. Illumination is provided by a custom built (SeaScan Inc), 2 cm thick, collimated light sheet. A Sea-Bird SBE19 SeaCat profiler equipped with a transmissometer and fluorometer provides environmental data.

IMPACT/APPLICATIONS

This study will yield an instrument capable of imaging zooplankton-sized particles in waters to depths of 250 m while simultaneously collecting data on bio-physical parameters at comparable spatial scales. By coupling a high-resolution camera capable of sampling at up to 4 Hz, with a flexible zoom lens, we will be able to adjust the image volume for specific applications and different target size ranges. ZOOVIS will fill a niche between towed optical systems such as the Video Plankton Recorder and moored systems such as the autonomous vertically profiling plankton observatory. ZOOVIS will be a shipboard instrument capable of rapidly collecting vertical profiles within surveyed areas. Horizontal distances between casts will be controlled by the user and scaled to match the patch structure of features of interest. Interpolation between casts within depth strata will provide a mechanism for volumetrically rendering the distributions of taxa and environmental parameters.

Applications include, but are not limited to: zooplankton surveys, ground-truthing of high-frequency acoustic backscatter profiles, and determination of the distribution and size structure of biotic and abiotic particles in the oceans.

TRANSITIONS

Our instrument will provide data on the spatial variation of zooplankton abundance and the size distributions of small particles on vertical scales of less than one meter, and horizontal scales of tens to thousands of meters. Such data are an essential for ground-truthing acoustics data and constraining the estimation of biomass from multi-frequency acoustic backscatter data (inverse problem). One of the PI's (Benfield) is currently involved in NSF/GLOBEC research using an ONR-funded vehicle (BIOMAPER II) in the Gulf of Maine. In that study, zooplankton data are provided by a Video Plankton Recorder on BIOMAPER II and a MOCNESS. We have shown that optical data can be used to extract biomass data from acoustics (Benfield et al. 1998). With ZOOVIS, we will have a comparable ground-truthing capability for acoustic surveys in the Gulf of Mexico and other regions (including structurally complex areas where towed instruments may become fouled). Insights gained from comparisons of the patterns of zooplankton distributions in the shelf waters off New England and the Gulf of Mexico will help us to understand how zooplankton and physical factors are related in coastal waters. Given the Navy's focus on littoral operations, this information will be useful for understanding and predicting spatial variation of sound-scattering organisms.

RELATED PROJECTS

ZOOVIS will be used in 2000 to collect data on the spatial and temporal variation in zooplankton distributions at a Gulf of Mexico petroleum platform. This study funded by the Minerals Management Service, is designed to identify trophic linkages between zooplankton and medium-sized pelagic fish predators at petroleum platforms. Mr. Sean Keenan is pursuing this study for his M.S. research at LSU.

We have also proposed ZOOVIS to collect mesozooplankton abundance data within an-NSF sponsored Long-Term Ecological Research (LTER) study proposed by Rabalais et al. "LTER: Linkages between the Mississippi River watershed and the Gulf of Mexico coastal ecosystem."

REFERENCES

Benfield, M.C., P.H. Wiebe, T.K. Stanton, C.S. Davis, S.M. Gallager and C.H. Greene. 1998. Estimating the spatial distribution of zooplankton biomass by combining Video Plankton Recorder and single-frequency acoustic data. *Deep-Sea Research Part II*, 45: 1175–1199.

PUBLICATIONS

No publications directly related to this project were generated during the first year of the investigation.